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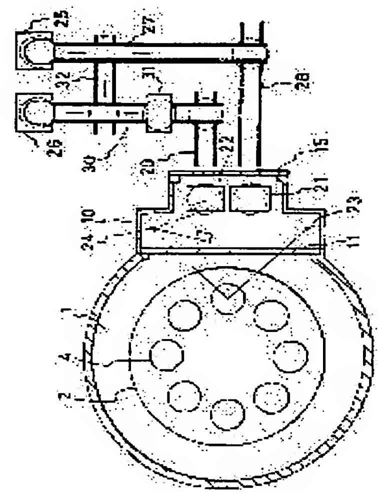
(71)Applicant : TOSHIBA MACH CO LTD
(72)Inventor : KOMIYAMA SAN
OBUCHI NORIYUKI
MATSUO TAKESHI

(54) SEMICONDUCTOR PROCESSOR

(57)Abstract:
PURPOSE: To improve the productivity of a semiconductor processor by arranging loading and unloading cassettes in a load locking chamber to load and unload a plurality of wafers to remarkably reduce the numbers of switching operations of a shutter and the pressure reducing operations.
CONSTITUTION: When a plasma process is finished, a first shutter 11 is opened in the state that a load locking chamber 10 is predetermined vacuum degree, wafers 4 are unloaded in number loaded on a table 2 in an unloading cassette 22 by a turning chuck 24. The unloaded wafers 4 are sequentially conveyed out from the lower portion of the cassette 22 by closing the shutter 11, introducing N2 gas into the chamber 10 to return to the atmospheric pressure and then opening a second shutter 15, and sequentially contained from above through a third conveying path 29 in a third cassette 31.



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SPECIFICATION

1. Title of the Invention

Semiconductor Processing Apparatus

2. Claims

(1) A semiconductor processing apparatus characterized by comprising:

a process chamber;

a load lock chamber connected to the process chamber via a first shutter which is capable of opening/closing;

a load cassette and an unload cassette provided in the load lock chamber, to be used for housing a semiconductor substrate;

a semiconductor substrate feeder provided between the cassettes and a semiconductor substrate supporting member in the process chamber;

a first cassette and a second cassette connected to the load lock chamber via a second shutter which is capable of opening/closing and conveyer systems, for supplying the semiconductor substrate to the load cassette and collecting the semiconductor substrate housed in the unload cassette; and

a third cassette for temporarily storing the semiconductor substrate, the third cassette being provided in at least one of the respective two conveyer systems separately placed between the load cassette and the unload cassette and between the first cassette and the second cassette.

(2) The semiconductor processing apparatus according to claim 1, wherein each of the load cassette, the unload cassette, the first, the second and the third cassette has a structure in which the semiconductor substrate is conveyed thereto through each of upper parts thereof and is conveyed out therefrom through each of lower parts thereof.

(3) The semiconductor processing apparatus according to claim 1, wherein the conveyor systems includes another conveyer system for conveying the semiconductor substrate from part of the third cassette provided in one of the conveyer systems to the other conveyor system, the part of the third cassette being close to the first cassette or the second cassette.

(4) The semiconductor processing apparatus according to claim 1, wherein the conveyance of the semiconductor substrate from the first cassette or the second cassette to the load cassette and the conveyance of the semiconductor substrate from the unload cassette to the third cassette are performed simultaneously in a state where the second

shutter is opened.

(5) The semiconductor processing apparatus according to claim 1, wherein the number of semiconductor substrates to be conveyed to the load cassette is an integer multiple of the number of semiconductor substrates for one batch processing in the process chamber and smaller than the maximum number of semiconductor substrates to be housed in the first cassette or the second cassette; and

wherein the semiconductor substrates are not conveyed out from the third cassette until the number of semiconductor substrates housed in the third cassette becomes equal to that of semiconductor substrates conveyed out from the first cassette or the second cassette.

(6) The semiconductor processing apparatus according to claim 1, wherein the number of semiconductor substrates conveyed to the load cassette is so controlled as to be equal to or smaller than that of semiconductor substrates processed in the process chamber; and

wherein the conveyance of semiconductor substrates to the load cassette and the conveyance of semiconductor substrates from the unload cassette to the third cassette are performed during execution of a sequence in the process chamber.

3. Detailed Description of the Invention

[Utilization Field in Industry]

The present invention relates to processing apparatuses used for manufacturing semiconductors and, particularly, to a processing apparatus having a load lock chamber.

[Prior Art]

Shown in Figs. 4 and 5 are known processing apparatus of this type. More specifically, the processing apparatus is a diode parallel plate plasma CVD apparatus, and a process chamber is denoted by 1 in the drawings. A rotatable table 2 for supporting semiconductor substrates (hereinafter referred to as wafers) 4 is provided in the process chamber, and the wafers 4 are placed on the table 2 along a direction of rotation via a plurality of projected pins 3. The projected pins 3a are retracted by the operation of cylinders 5 shown in Fig. 5. An electrode 6 is provided in the process chamber at an upper part in such a fashion that the electrode 6 is apart from and opposed to the table 2, and a radio frequency power unit 7 is connected to the electrode 6. Reference numeral 8 denotes an evacuation pipe connected to the process chamber 1, and reference numeral 9 denotes a nozzle for introducing a reaction gas to the process chamber 1.

A load lock chamber 10 is provided adjacent to the reaction chamber 1, and the load lock chamber 10 and the

reaction chamber 1 is separated from each other by a first shutter 11 which is capable of opening and closing. A swing chuck 12 is provided rotatably in the load lock chamber 10 to load and unload the wafers 4. Reference numeral 13 denotes an evacuation pipe connected to a top face of the load lock chamber 10.

A wafer conveying device 14 is provided adjacent to the load lock chamber 10, and the wafer conveying device 14 and the load lock chamber 10 are separated from each other by a second shutter 15 which is capable of opening and closing.

A fist cassette 16 is disposed at one side of the wafer conveying device 14 and a second cassette 17 is disposed at the other side of the wafer conveying device 14. A conveyor belt 18 runs to convey the wafers 4 housed in the first cassette 16 to a point A. A conveyor belt 19 runs to convey wafers placed on a point B to the second cassette 17, so that the wafers are housed in the second cassette 17.

When a start button for starting operation is turned on, processing is performed automatically in accordance with a predetermined sequence as follows: After the wafers 4 placed on the table 2 are processed, a cylinder 11a moves to open the first shutter 11, and the swing chuck 12 swings to an unload position C on the table 2 to chuck the wafers

4 and then reaches a standby position D in the load lock chamber 10. After that, the first shutter 11 is closed, and a gas is supplied via a purge gas inlet 20 to change a pressure in the load lock chamber 10 to an atmospheric pressure. Then, the second shutter 15 is opened, and the swing chuck 12 swings to the point B on the conveying device 14. The wafers 4 are unloaded at the point B by the swing chuck 12, and the conveyor belt 19 runs to house the wafers 4 in the second cassette 17. After that, the swing chuck 12 swings further to the point A to chuck the wafers 4 conveyed from the first cassette 16. Then, the swing chuck 12 swings in a reverse direction to reach the standby position D in the load lock chamber 10. At this time, the second shutter 15 is closed, and an evacuation device (not shown) is actuated to evacuate the load lock chamber 10 via the evacuation pipe 13. When a degree of vacuum in the load lock chamber 10 is thus changed to be identical with that in the process chamber 1, the first shutter 11 is opened again and loading to a load position E on the table 2 is performed by the swing chuck 12 (in practice, the table 2 rotates to the load position E to wait thereat).

The above operation is repeated to process the wafers 4.

[Problems to be Solved by the Invention]

However, a problem of low productivity has been

detected in the conventional apparatuses since it is necessary to open and close the shutters 11 and 15 as well as to repeat the gas purge and discharge of the load lock chamber 10 every time the wafer 4 is unloaded from or loaded to the process chamber 1.

Also, in the case where a temperature of the table 2 is raised to about 300°C and is not cooled down soon after the reaction, such as in the case of performing the plasma CVD, a remarkable time difference (about 10 minutes, for example) is generated between a wafer loaded first and a wafer loaded last in the subsequent batch of wafers. Therefore, although the last wafer or the second last wafer is processed immediately after loading, a temperature of the wafer is lower than that of other wafers so that a result of DEPO varies from those of other wafers leading to a variation in thickness in the batch, thereby deteriorating quality of wafers. In order to avoid such deterioration in quality, it has been necessary to leave the table for a while after completion of the loading until the temperature is stabilized, thereby further lowering the productivity.

The present invention has been achieved in view of the above circumstances, and an object of the present invention is to provide a semiconductor processing apparatus which is capable of processing semiconductor

substrates without opening and closing shutters every time the semiconductor substrates are loaded to and unloaded from a process chamber and is capable of processing the semiconductor substrates without causing variation in temperature thereof.

[Means for Solving the Problem]

In order to solve the above problems, a semiconductor processing apparatus of the present invention includes a load cassette and an unload cassette disposed in a load lock chamber, a first cassette and a second cassette for supplying semiconductor substrates to the load cassette and collecting the semiconductor substrates conveyed out of the unload cassette via a conveyor system; and a third cassette which is provided on the conveyer system and temporarily stores the semiconductor substrates.

[Function]

By loading and unloading a plurality of wafers to and from the load cassette and the unload cassette provided in the load lock chamber, the number of opening and closing operations of the shutters and the number of pressure increase/reduction operations are reduced and temperatures of the semiconductor substrates are made uniform. Also, even in the case where the number of semiconductor substrates that can be housed in each of the first and the second cassettes is not the integer multiple, processed

semiconductor substrates and non-processed semiconductor substrates are conveyed to and out of the load lock chamber sequentially by use of the temporary storage by the third cassette.

[Embodiments]

Hereinafter, the present invention will be described in conjunction with one embodiment shown in Figs. 1 and 2. The components shown in Figs. 4 and 5 are denoted by the identical reference numerals in Figs. 1 and 2 and the descriptions thereof are omitted. A load cassette 21 and an unload cassette 22 are provided in a load lock chamber 10, and swing chucks 23 and 24 serving as feeders for loading wafers to and unloading wafers from a table 2 are also provided in the load lock chamber 10. A first cassette 25 and a second cassette 26 are provided outside the load lock chamber 10. The first cassette is connected to the load cassette 21 of the load lock chamber 10 via a first conveyer passage 27 and a second conveyor passage 28, and the second cassette 22 is connected to the unload cassette 22 of the load lock chamber 10 via a third conveyor passage 29 and a fourth conveyor passage 30. A third cassette 31 is provided on the fourth conveyor passage 30 at an intermediate position. The first conveyor passage 27 and the fourth conveyor passage 30 are connected to each other via a fifth conveyor passage 32 which is

perpendicular to the conveyor passages 27 and 30.

Each of the load cassette 21, the unload cassette 22, and the first to third cassettes 25, 26, and 31 is provided with a sensor 33 for detecting the presence or absence of wafers 4 as well as an elevator mechanism (not shown) for elevating the wafers 4 at a predetermined pitch in response to a signal from the sensor 33. Thus, the wafers 4 to be conveyed out from each of the cassettes 25, 26, and 31 sequentially pass through a lower part of the cassette and wafers to be conveyed in to each of the cassettes 25, 26, and 31 sequentially pass through an upper part of the cassette.

When the wafers 4 is processed, a second shutter 15 is opened to convey the wafers 4 out of the first cassette 25 sequentially through the lower part via the first conveyor passage 27. The wafers 4 thus conveyed out are then conveyed to the load cassette 21 through the upper part via the second conveyor passage 28 to be collected therein sequentially. After that, the second shutter 15 is closed, and the air in the load lock chamber 10 is discharged from a discharge pipe 13 to achieve a predetermined degree of vacuum (in general, since a degree of vacuum in a process chamber 1 is continuously kept in a predetermined range, the degree of vacuum in the load lock chamber 10 is set to a level equal to or larger than that

of the process chamber 1). Then, a first shutter 11 is opened, and the swing chuck 23 takes out the wafers 4 one by one through the lower part of the load cassette 21 so as to place the wafers 4 on a table 2. After that, the first shutter 11 is closed, and plasma processing is started.

After completion of the plasma processing, the first shutter 11 is opened in the state where the load lock chamber 10 is kept at the predetermined degree of vacuum, so that the swing chuck 24 unloads the wafers (the number of the wafers is 8) which have been loaded on the table 2 to the unload cassette 22. After the first shutter 11 is closed and the pressure in the load lock chamber 10 is returned to the atmospheric pressure by introduction of N_2 gas, the second shutter 15 is opened so that the unloaded wafers 4 are sequentially conveyed out from the unload cassette 22 through the lower part to be conveyed to the third cassette 31 through the upper part via the third conveyor passage 29. After the wafers 4 are temporarily stored in the third cassette 31, they are conveyed to the second cassette 26 to be stored until completion of subsequent processing in the process chamber and removal of a subsequent batch of wafers 4 from the load lock chamber 10 via the unload cassette 22. In the case where all of the wafers 4 for one batch conveyed out from the load lock chamber 10 can be stored in the second cassette 26, the

temporary storage by the third cassette 31 is not necessary and the wafers 4 can simply be passed to the second cassette 26 by way of the conveyor passage 30.

In the case where the number of wafers that the second cassette 26 can store is 25 and the number of wafers for one batch processing in the process chamber is 8, the number of wafers 4 in the second cassette 26 reaches 25 of the storage capacity when the first wafer included in 8 wafers of the fourth batch is conveyed to the second cassette 26 to be stored therein after the processing (the number of wafers for 3 batches is 24). The remaining 7 wafers 4 cannot be stored unless the second cassette 26 is replaced by a new one; however, thanks to the third cassette 31 provided on the conveyor passage 30 in this apparatus, 8 wafers 4 for one batch are sequentially conveyed out from the load lock chamber 10 to be stored temporarily in the third cassette 31 irrelevant from the number of wafers stored in the second cassette 26 or the presence or absence of the second cassette 26. Then, during the period from the completion of subsequent processing to the removal of the wafers 4 from the load lock chamber 10, one of the wafers in the third cassette 31 is sent to the second cassette 26 to fill the second cassette 26 and the second cassette 26 is replaced with a new one with the remaining seven wafers 4 being stored in

the third cassette 31. Thus, it is possible to convey the wafers 4 out from the load lock chamber 10 by one batch sequentially without fail and in a short time, and it is easy to control the timing of replacing the second cassettes 26 in accordance with the subsequent processing.

This holds true for the case where the wafers 4 are supplied from the first cassette 25 to the load lock chamber 10. Another third cassette 31 (not shown) may be provided on the conveyor passage 27 or 28.

In addition, a plurality of first cassettes 25 and second cassettes 26 may be provided along the conveyor passages 27 and 30 or to convey the wafers automatically in accordance with the precedent and subsequent processing in the sequential processing performed by the apparatus.

Although the example of supplying the unprocessed wafers 4 from the first cassette 25 and storing the processed wafers 4 in the second cassette 26 is described above, the wafers 4 conveyed out from the first cassette 25 may be returned to the first cassette 25 in the case where the processing is controlled on the wafers 4 by the unit of cassette such as numbering of the cassettes. In this case, the wafers 4 are conveyed out from the first cassette 25 to be processed, then conveyed out from the load lock chamber 10 to be stored in the third cassette 31, and then returned to the first cassette 25 via the fifth conveyor passage 32

and the first conveyor passage 27 when the first cassette 25 is thus emptied. Also, in this case, when the first cassette 25 is emptied by supplying all the wafers 4, the unprocessed wafers 4 are supplied to the load lock chamber 10 from the second cassette 26 via the fourth, the fifth, the first, and the second conveyor passages 30, 32, 27, and 28. The conveyance of the processed wafers 4 from the third cassette 31 to the first cassette 25 is performed during the supply of the wafers 4 from the second cassette 26. The timing of conveying the wafers 4 from the third cassette 31 to the first cassette 25 may be at the time point when 24 wafers (for 3 batches) are stored, and the first wafer in the fourth batch is simply passed through the third cassette 31 to return to the first cassette 25 while the rest of wafers of the fourth batch are stored in the third cassette 31.

Further, by conveying the wafers to and from the cassettes 21, 22, 25, 26, and 31 by the unit of cassette so as to prevent a change in order of the wafers 4 in each of the cassettes as well as by conveying the wafers 4 out of the cassette through the lower part and conveying the wafers 4 in the cassette through the upper part, the order of the wafers 4 returned to the first cassette 25 after being conveyed out of the first cassette 25 is unchanged, thereby making it possible to administrate the wafers 4 not

only by the unit of cassette but also by the order in the cassette. In this case, the number of wafers to be stored in each of the load cassette 21, the unload cassette 22, and the third cassette 31 is not necessarily the same as that of each of the first and the second cassettes 25 and 26. It is possible to set the number of wafers to be stored in each of the cassettes 21, 22, and 31 to 24 (for 3 batches) to convey one wafer which is a fraction to the next cassette before a conveyance of wafers from the first and the second cassettes 25 and 26 in the above example. Also, in this case, the second shutter 15 close to the atmosphere of the load lock chamber 10 is not necessarily opened for every batch processing and it is needed for the second shutter 5 only to be opened for the conveyances of wafers to and from the load cassette 21 and the unload cassette 22.

According to this embodiment, the conveyance time of the wafers 4 overlaps with the processing time of the wafers 4 in the process chamber 1, thereby improving the production efficiency and facilitating the pressure increase/reduction.

Also, by adapting the load cassette 21 and the unload cassette 22 for the number of wafers for one batch, it is possible to downsize the load lock chamber 10.

In addition, with the lot management (cassette

management), a defective wafer may be generated in a process before processing by the processing apparatus to cause reduction in the number of wafers in each of the first and the second cassettes 25 and 26. In such a case, comparison among the first to the third cassettes 25, 26, and 31 may be performed based on the software so that the return of wafers is controlled in such a manner that, in the case where the number of wafers 4 to be loaded from the first cassette 25 is 24, the wafers are returned to the first cassette 25 after 24 wafers are conveyed to the third cassette 31.

Although the example of processing eight wafers 4 as one batch using the cassettes each can store 25 wafers has been described in the foregoing, when the number of wafers to be stored in a cassette and the number of wafers for one batch are divisible, such as in the case of using a cassette which stores 24 wafers or a cassette storing 25 wafers with the number of wafers for one batch being set to 5, the production efficiency is further improved.

By increasing the number of each of the first to the third cassettes and the number of conveyor lines connected thereto, the relationship between replacement and standby is improved in terms of efficiency.

When the conveyances to and from the first and the second cassettes 25 and 26 are performed by using a robot

or the like, further automation is achieved.

Alternatively, this invention may have the structure shown in Fig. 3. The apparatus shown in Fig. 3 is provided with a load lock chamber 41 disposed on one side of a process chamber and a load lock chamber 42 disposed on the other side of the process chamber; a load cassette 43 disposed in the load lock chamber 41; an unload cassette 44 disposed in the load lock chamber 42; a first cassette 45 for supplying wafers to the load cassette 43; a third cassette 46; and a second cassette 47, wherein the wafers conveyed out from the unload cassette 44 are collected in the second cassette 47 via the third cassette 46.

Of course, various modifications can be made so far as the modifications are within the scope of the invention.

In addition, in the conventional electron beam lithography systems, an apparatus that can load and unload the cassette itself to and from the load lock chamber may be used; however, the following problems are detected with the use thereof.

That is, contaminants are brought in the load lock chamber 10 when the cassette is conveyed to the load lock chamber 10 to cause deterioration in quality.

The number of wafers to be stored in the cassette is limited to reduce the productivity.

Moreover, an opening required for conveying the

cassette to the load lock chamber 10 is disadvantageous from the stand point of the structure of the load lock chamber 10 and is not suitable for automation.

[Effect of the Invention]

As described in the foregoing, according to this invention, the load cassette and the unload cassette are disposed in the load lock chamber to load and unload a plurality of wafers, thereby remarkably reducing the number of shutter opening/closing operations and the number of pressure reduction operations. Thus, productivity and quality can be enhanced.

Further, in the case where the number of wafers to be stored in each of the first and the second cassettes is not a multiple integer of the number of wafers for one batch process in the process chamber and there is a fraction, an effect of conveying the wafers to the load lock chamber sequentially in a short time is achieved thanks to the temporary storage by the third cassette.

4. Brief Description of Drawings

Fig. 1 is a cross-sectional view of a semiconductor manufacturing apparatus according to one embodiment of the present invention; Fig. 2 is a longitudinal sectional view of the semiconductor manufacturing apparatus; Fig. 3 is a cross-sectional view showing another embodiment; Fig. 4 is

a cross-sectional view showing a conventional example; and Fig. 5 is a longitudinal sectional view showing the conventional example.

1 ... process chamber; 2 ... table (semiconductor substrate supporting member); 4 ... wafer (semiconductor substrate); 10, 41, 42 ... load lock chamber; 11 ... first shutter; 15 ... second shutter; 21, 43 ... load cassette; 22, 44 ... unload cassette; 23, 24 ... swing chuck (feeders); 25, 45 ... first cassette; 26, 47 ... second cassette; 27, 28, 29, 30, 32 ... conveyor system.

7. Amendment

(1) "About 10 minutes" on line 4 of page 6 is to be replaced by "about 10 minute's difference".

(2) "Although" on line 7 of page 6 is to be replaced by "When".

(3) "The unloaded wafers 4" on line 15 of page 9 is to be deleted.

(4) "In this case" on line 15 of page 11 to "the cassettes" on line 9 of page 12 is to be replaced by "In this case, the number of wafers conveyed out from the fist cassette 25 is counted, and the conveyance to the cassette 21 may be either one of conveyance of wafers for one batch process in the process chamber and conveyance of all the wafers 4 in the cassette 25. In the former conveyance, the operation is so controlled as to return the wafers to the cassette 25 via the conveyor passages 30, 32, and 27 after the number of processed wafers 4 to be conveyed to the cassette 31 becomes the same as the counted number of the wafers conveyed out from the cassette 25. In the latter conveyance, the operation is so controlled as to store the wafers in the cassette 22 until the number of wafers 4 conveyed into the cassette 22 becomes the same as the counted number of the wafers conveyed out from the cassette 25 and then the wafers 4 are conveyed from the cassette 22 to the cassette 31 when the second shutter 15 is opened for

the conveyance from the second cassette 26 to the cassette 21, thereby preventing the wafers 4 from the cassette 25 from being mingled among the wafers 4 from the cassette 26 to achieve an effective conveyance.

Note that the timing of the conveyance from the third cassette 31 to the cassette 25 in the former conveyance and the timing of the conveyance from the cassette 22 to the first cassette 25 via the third cassette 31 in the latter conveyance may be at the time point as described above when the wafers for one batch or 24 wafers 4 (for three batches) are stored in the cassette 31 or the cassette 22 without waiting until the storage of all the wafers from the first cassette 25, and the first wafer of the fourth batch may be returned to the first cassette 25 to store the rest of the wafers of the fourth batch in the third cassette 31 or the cassette 22, thereby making it possible to reduce the time of waiting for the conveyance when the conveyance of the wafers from the first cassette switches to the conveyance of the wafers from the second cassette 26.

Further, by storing all the wafers 4 to be returned to the first cassette 25 in the third cassette 31 before they are returned to the first cassette 25 as described above".

(5) "In this case" to "cassette 22." on lines 16 to

30 of page 12 is to be deleted.

(6) "In addition" on lines 9 of page 13 to "cassette 31" on line 20 of page 13 is to be deleted.

(7) "when the number of wafers to be stored in a cassette and the number of wafers for one batch are divided out" on lines 23 to 25 of page 13 is to be replaced by "when the number of wafers to be stored in a cassette is an integer multiple of the number of wafers for one batch".

(8) "pressure reduction operations" on line 9 of page 15 is to be replaced by "pressure increase/reduction operations".